CLAIMS

1. A signal estimation method, comprising:

obtain at least one input state parameter;

obtaining at least one estimate feature of an estimated signal from said at least one input state parameter from an estimation model, wherein the estimation model maps a relationship between at least one state parameter and at least one feature; and

constructing the estimated signal from said at least one estimated feature.

2. The method of claim 1, wherein the estimated signal is at least one selected from the group consisting of an actual load and a response to a load.

3. The method of claim 1, wherein said at least one estimated feature comprises at least one mode amplitude associated with at least one mode shape.

4. The method of claim 3, wherein said at least one mode amplitude is a plurality of mode amplitudes and said at least one mode shape is a plurality of mode shapes, and wherein the constructing step comprises synthesizing said plurality of mode amplitudes with said plurality of mode shapes to obtain the estimated signal.

5. The method of claim 1, wherein the estimation model is generated by:

obtaining a plurality of sensor-specific signals from a plurality of sensors; and

combining the plurality of signals to obtain a composite estimation model.

6. The method of claim 1, wherein the estimated signal from the constructing step acts as a virtual sensor output.

7. The method of claim 6 ,wherein the method further comprises combining the virtual sensor output with at least one physical sensor output.

8. The method of claim 1, wherein said at least one estimated feature comprises a plurality of estimated features, and wherein the estimation model corresponds to a plurality of estimated signals, and wherein the method further comprises:

separating the plurality of estimated features into groups, each group corresponding to one of said plurality of estimated signals; and

conducting the constructing step on each group.

9. A signal estimation method, comprising:

obtaining at least one input state parameter;

obtaining at least one estimated variable feature from said at least one input state parameter via an feature estimation model, wherein the feature estimation model maps relationships between at least one state parameter and at least one variable feature; and

constructing an estimated signal from said at least one estimated variable feature and at least one fixed feature.

10. The method of claim 9, wherein said at least one input state parameter corresponds to at least one system operating state.

11. The method of claim 9, wherein said at least one estimated variable feature comprises at least one mode amplitude, and wherein said at least one fixed feature comprises at lest one mode shape.

12. The method of claim 11, wherein said at least one mode amplitude is a plurality of mode amplitudes and said at least one mode shape is a plurality of mode shapes, and wherein the constructing step comprises synthesizing said plurality of mode amplitudes with said plurality of mode shapes to obtain the estimated signal.

13. The method of claim 9, wherein the signal estimation model comprises a plurality of local signal estimation models generated by partitioning a plurality of input state parameters and said plurality of estimated variable features and generating each of said local models within each partition.

14. The method of claim 13, wherein each local model corresponds to a regime having a selected range of values of state parameters.

15. The method of claim 14, wherein the regime is at least one of a system operating regime and a system configuration.

16. The method of claim 9, wherein the estimated signal from the constructing step acts as a virtual sensor output, and wherein the method further comprises combining the virtual sensor output with at least one physical sensor output.

17. The method of claim 9, wherein the signal estimation

model corresponds to a plurality of estimated signals, and wherein the method further comprises:

separating the plurality of fixed features into groups, each group corresponding to one of said plurality of estimated signals; and conducting the constructing step on each group using the same estimated variable features for each group and the fixed features corresponding to a given group.

18. The method of claim 9, wherein the estimated signal is at least one selected from the group consisting of an actual load and a response to a load.

19. A method of generating a signal estimation model comprising:

obtaining an actual signal during operation of a system;

obtaining at least one state parameter during the same operation conducted for step of obtaining of the actual signal;

extracting at least one fixed feature and at least one variable feature from the signal;

constructing a variable feature estimation model that maps said at least one variable feature by said at least one state parameter in the feature estimation model; and

constructing a synthesis model that synthesizes an estimated signal from at least one variable feature obtained using the feature estimation model and at least one fixed feature.

20. The method of claim 19, wherein said at least one variable feature comprises at least one mode amplitude, and wherein said at least one fixed feature comprises at least one mode shape.

21. The method of claim 20, wherein said at least one mode amplitude comprises a plurality of mode amplitudes and said at least one mode shape comprises a plurality of mode shapes, and wherein said plurality of mode shapes are a plurality of functions, and wherein said plurality of mode amplitudes are coefficients for said plurality of mode shapes.

22. The method of claim 19, wherein the signal estimation model comprises a plurality of local signal estimation models generated by partitioning said plurality of state parameters and said plurality of features according to regimes and generating each of said local signal estimation models within each partition.

23. The method of claim 22, wherein each local model corresponds to a regime having a selected range of values of state parameters.

24. The method of claim 19, further comprising validating the signal estimation model by:

generating an estimated signal using known state parameters; and

comparing the estimated signal with a signal measured during operation of the part with state parameters matching the known state parameters.

25. The method of claim 19, wherein the signal estimation model is generated by:

obtaining a plurality of sensor-specific signals from a plurality of load sensors; and

combining the plurality of sensor-specific signals to obtain a composite signal estimation model.

26. The method of claim 19, wherein the extracting step comprises obtaining a N-dimensional array from the actual signal and constructing said at least one variable feature and said at least one fixed feature from the array, wherein $N \geq 2$.

27. The method of claim 19, wherein the estimated signal is at least one selected from the group consisting of an actual load and a response to a load.

28. A load signal estimation system for estimating at least one of a load on a part and a response to a load, comprising:

a memory that stores a model coefficients library and a mode shape library, wherein the model coefficients library is part of an estimation model that maps a relationship between at least one state parameter and at least one mode amplitude; and

a processor that receives at least one input state parameter, obtains at least one mode amplitude corresponding to said at least one input state parameter, and constructs an estimated load signal from said at least one mode amplitude and at least one mode shape taken from the mode shape library.

29. The load signal estimation system of claim 28, wherein the processor acts as a virtual sensor such that the estimated load signal acts as a virtual sensor output.

30. The load signal estimation system of claim 29, wherein the processor combines the virtual sensor output with at least one physical sensor output.

31. The load signal estimation system of claim 28, wherein the estimation model is a composite estimation model constructed from a plurality of sensor-specific load signals output by a plurality of load sensors.